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An Introduction to This Issue

WINTER is a good time for farmers inside and outside the 153 erosion-control demonstration projects to think about pasture improvement and range management.

Contour furrowing has proved effective in conserving moisture, reestablishing vegetation and holding soils in the droughty, windy West, and in increasing plant growth and slowing run-off in the rainy East.

Mr. Newport's article discusses contour furrowing with particular reference to High Plains range lands. Page 139.

Dr. Dahl's article treats of the practice as applied to the Corn Belt. Page 141.

Mr. Brown contributes some very practical information on four types of furrows which are proving their worth in Region 1. Page 143.

While there is yet much to be learned about this instrument of erosion-control, it has already demonstrated its simplicity, its economy, its flexibility, and its efficiency under widely varied conditions.

There are some 800,000,000 acres in this country devoted to grazing. That is approximately 40 percent of the whole United States—more than twice the area in cultivation. There are perhaps 200,000,000 other acres—cut-over land and forest—used partly for grazing. The totals serve to open a window on a broad panorama of opportunity—an opportunity made more important by the present poor condition of so many pastures.

Mr. Semple gives a swift review of contour furrowing as it occurs in each of six regions. Page 134.

Reports from the field say that by encouraging farmers to construct contour furrows, the Soil Conservation Service has stimulated their interest in the entire program of pasture improvement. Many times farmers who have creased one part of their farms with furrows have later asked that contour lines be run on the remainder of their pastures. They have found that small furrows spaced at short intervals interfere neither with the mowing of weeds nor with the moving of farm implements across the fields. They have used their own tools, have not been put to large expense.

The back cover illustrates the favored type of construction.

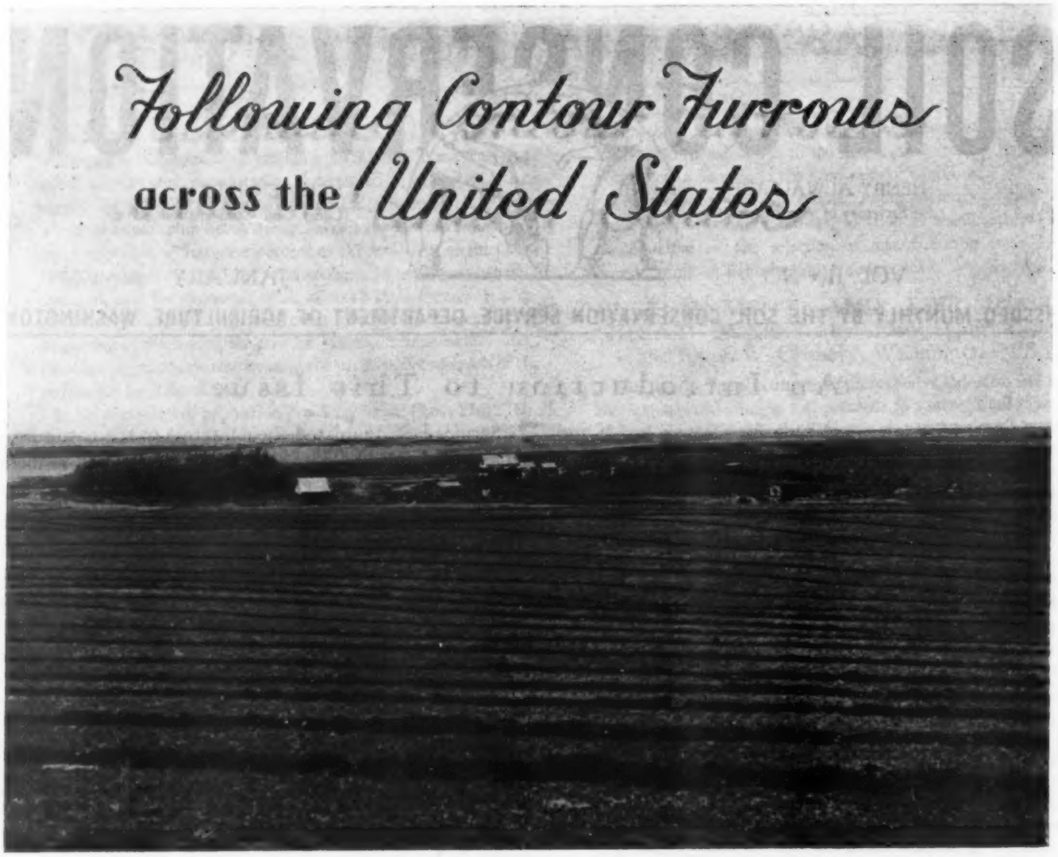
West of the Mississippi, where moisture is a limiting factor in production, contour furrowing of pasture and range lands has proceeded more rapidly than elsewhere. Farther east, it has proved its worth in slowing the pace of running water; here, instead of acting to keep good soil out of the air, it serves to keep good soil out of the streams.

PROJECTS are eager to demonstrate to the farmer how he may conserve his soil at least expense. In every region short-cuts and cost-reductions are being effected through intelligent planning, through the substitution of vegetation for elaborate structures wherever feasible, through the adaptation of equipment already at hand, and through making use of the information accruing from both operations and research. News of such progress will be found in these pages from month to month.

Dr. Buie starts off the series with a brief account of economies being wrought in Region 2. Page 151.

The Editor.

Following Contour Furrows across the United States



By A. T. Semple[1]

IN REGION 1, as elsewhere, the average farm pasture has too little cover to hold the torrential summer rains, with the result that there is frequently a shortage of moisture during midsummer. Contour furrows have considerable value here as a means of holding the rainfall until it can be absorbed by the soil. It has been observed that rainfall penetrates 6 to 18 inches deeper on land that is furrowed. By using equipment which the farmers have, and by plowing small furrows close together, the work can be done very cheaply and as much as 80 percent of heavy rains can be held.

In one instance such conservation of moisture provided sufficient pasturage for the farm stock throughout July. It was evident that without the furrows there would have been no pasturage worthy of the name. And yet, a common mistake is to keep stock on untreated pastures, where they tramp out and eat into the ground the little vegetation that is there. Such a practice usually accelerates erosion and decreases still further the capacity of the soil to sponge up water.

In making the furrows, the plow is "jumped" out of the ground at distances of 15 to 50 feet, leaving blocks 3 to 6 feet long to stop the drainage if the grooves are not exactly on the contour. With a little planning, it is believed that most farmers will be able to put in such furrows without an instrument to establish contour lines.

When soil moisture conditions are optimum for plowing, single furrows are generally sufficient. When the soil is so dry that the furrow slice crumbles, leaving breaks through which water will flow, a second furrow slice laid on the first will help to fill the breaks. It is considered a good practice to line, fertilize, disc, seed,

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Typical pasture being contour furrowed in Marshall County, W. Va., where field slopes commonly vary from 15 to 30 percent. There has been severe erosion in the pasture just beyond the one being treated.

and roll or cultipack these furrows. Furthermore, it is desirable to keep stock off of such pastures until the disturbed soil is well covered with vegetation. At the close of October 1936, 2,067 acres of contour furrows had been completed in Region 1.

South and Southeast

In Region 2, Mississippi leads in this practice. Contour furrowing of pastures has been employed satisfactorily for several years at the coastal plain experiment station, McNeil.

Contour furrows on project areas are spaced from 10 to 30 feet apart horizontally. No definite vertical interval is used. The slopes on which contour furrows are constructed range from 4 to 15 percent. Construction usually is done with mule-drawn equipment. The completed furrows have a base width of about 6 feet and a height of from 6 to 12 inches. Such work may more properly be called contour ridging, since several furrows are thrown together. Small gullies are crossed, but no attempt is made to cross large gullies. The ends of the furrows are turned slightly up-grade as large gullies are approached to prevent the delivery of water into the latter. Generally, barriers are formed by throwing a few shovels of soil into the furrow at intervals of approximately 50 feet. Where small gullies are crossed sufficient filling is done to protect the ridges from breaking at the gullies.

Ordinarily, where contour ridges are constructed on land already covered with sod, the entire strip broken is revegetated naturally by the end of the first growing season afterward.

Low Cost Recorded

The following information is taken from the report of the Port Gibson project which is located on the rich loessial soils of Claiborne and Jefferson Counties. On account of the very broken topography, much of the land is too steep for clean cultivation.

Contour ridges are constructed with a 10-inch Kelly or Oliver plow making three rounds or six furrows with a three-mule team. The furrow on the upper side of the contour is then cleaned out with a home-made "V-drag", the wing being only 3 feet long so as not to open the ditch too wide. Hand labor is then used to patch up weak places and to turn up the ends. This gives a ridge approximately 6 feet wide at the base and 10 inches high. Contours are run from 12 to 30 feet apart depending on the slope. The total cost of ridge construction averages around $2 per acre. This includes man labor and mule labor.

Disciplining a Creek

Such ridges have had a very noticeable effect on the overflow of bottom land. Before the work began, Baker's Creek would be overflowed as much as 4 feet after 3 or 4 inches of rainfall. During the winter of 1935–36, approximately 1,000 acres of pasture lands were contoured, all of which was near the head waters of the creek. Since this work was done, Baker's

A badly overgrazed and drought-depleted pasture in western Kansas, as it appeared April 24, 1936. Contour furrows about 10 feet apart were blocked from ridge to ridge at intervals of about 50 feet. This, of course, involved more hand labor than can ordinarily be justified.

Creek has not overflowed nor has the water been within 1½ feet of the top of the bank.

The effect on the growth of grasses during the hot, dry summer has been very noticeable. A strip from 10 to 15 feet wide along each ridge has stayed green all summer, whereas in the spaces midway between the ridges, the grass and clover has dried up and turned brown. The cattle grazed entirely on these green strips.

Most Objections Unfounded

Many objections, most of them imaginary, have been brought forward against contouring. "Can't be mowed": We find no trouble mowing contour ridges 6 feet wide and 10 inches high. "Destruction of vegetation": We find that by reseeding these 6-foot strips with quick-growing and permanent grasses the damage is soon overcome. The loosening of the soil and the holding of extra moisture will grow a new sod within 3 to 5 months.

Experience in Southwest

Although considerable contour furrowing has been done on range land in Region 8, this work is recent and results are not always evident.

Most of the furrows are of the double-ditch type and continuous, such as could be made by going across a field with a turning plow, then coming back, throwing the sod from the second furrow against that of the first, with a ditch left above and below the ridge. They are variously spaced, usually at about a 6-inch vertical interval.

On one project these furrows broke at frequent intervals, the result being an excellent water-spreading system. In general, however, the heavy rains of short duration caused the furrows to break at low places where in some instances serious gullying resulted.

Scattered Crescents

On one area where it was necessary to use hand labor, crescent-shaped trenches, shovel width, 6 inches deep and from 8 to 20 feet long, were dug, the soil being thrown into a ridge below the furrow. These crescent redoubts were staggered down the slope. They were particularly effective along, but not crossing, shallow drainageways and on steep hillsides. It was not necessary to run levels and to stake lines for this work, thus eliminating engineering costs. Native vegetation as well as planted seeds came into

the crescents in great abundance, and the water that could not be held by the trenches and banks spread downhill slowly with no erosive effects.

The Plow Takes a Hop

Another type of furrow that may replace much of the other work is being tried. This is a small discontinuous furrow that can be made with a 10-inch turning plow and a team, or other similar equipment. The plow is run approximately on the contour and is lifted out of the ground every 8 to 10 yards, leaving an unplowed gap of 2 or 3 feet. The sod is thrown up or down slope, depending on the direction of travel, and the furrows are from 8 to 15 feet apart on most range land. These can be made in this country for about 50 cents per acre and seem to be the most practicable and beneficial.

When rainfall is 14 inches or over contour furrows are worth while in this region. This is especially true where there is a grass sod.

In Region 9 contour furrowing in native grass pastures was started this year. The drought has been so severe that practically no data are available to show results. Emphasis is being placed on shallow furrows, closely spaced to provide adequate water-holding capacity and satisfactory distribution of the water, the reason being that the lateral movement of water in the soil is slight. However, many types of furrows are being tried out.

The implements being used are the three-row lister with the middle lister removed, the road plow, the regular turning plow, the two-way turning plow, a modified contour-furrowing machine developed at Mankato, Kans., and the small blade or terracer.

Where the sod is thick, and the soil is of heavy texture, the contour furrow-slicing machine does nicely. On light soils, rocky soils, and areas with limited sod, the machine will not work.

Three-Row Lister Adapted

On large acreages where a minimum cost of contour furrowing is essential, the three-row lister with the middle lister taken out is very practical and economical.

For demonstration and practical purposes, the two-way turning plow performs well. It is practical in that very little sod is disturbed and most farmers have turning plows, which can be operated with either horses or tractor.

Ridge growth of Russian thistles 2 months later. These, together with the larger storage of moisture in the soil, prepare the way for native grass and sweet clover.

Some of the earlier contour furrowing, done under very adverse soil and moisture conditions, cost as high as $1.88 per acre. More recent work, performed under more favorable conditions, cost as low as 25 cents per acre.

Making Use of Bermuda

In Region 7 success in establishing small chunks of Bermuda sod and small sprigs of Bermuda rhizomes on well-prepared contour ridges about six furrows wide has been remarkable. In the Muskogee-project area of 34,000 acres, over 3,200 acres of weedy, worn-out pasture land and abandoned fields are being brought back to productivity with just about the most perfectly erosion-proof covers imaginable. On slopes varying from 1 to 6 percent the average spacing of the ridges is about 20 feet. The farmers plow the furrows and work them down to make a good seedbed while the Soil Conservation Service surveys for the contour lines and does the planting with hand labor. Under favorable conditions, with large pastures and short distances to haul the sod, planting costs have been as low as $1 per acre with labor at 22 cents per hour.

Commonly the ridges are covered the first year by spacing the sod or sprigs in rows about 4 feet apart, one on either side of each ridge. The agreements provide that the farmers will plow two furrows around each ridge each year, until all the space between has been turned. Working the furrows down after plowing helps to smooth out the shoulder left by the plow and makes mowing easier. The ground must be plowed and worked well and the weeds kept down in order that the Bermuda grass may spread satisfactorily. A strip of ground shaded by weeds, shrubs, or trees serves as a barrier to the spread of Bermuda grass. Regions 2 and 4 are having similar success in planting Bermuda on contour ridges.

Texas, Arkansas, Louisiana

Region 4 has followed the plan of building contour ridges which consist of four furrows thrown together. Once settled, these have an effective height of 4 to 5 inches.

On the steeper slopes, the ridges are placed about 12 feet apart, while on the more gentle slopes they may be spaced as far as 25 feet apart. Although any large turning plow may be used for ridge construction, the recommended procedure is to make the first round with a 12-inch turning plow, and the other with a long-winged terracing plow. (For details of contour-ridge construction, members of the Soil Conservation Service are referred to pp. 33 and 34 of the Region 4 agronomy manual.)

In practically every instance contour-ridged pastures have shown a greater infiltration of rainfall when compared with pastures having no ridges, regardless of slope or cover. The infiltration was greatest just above the ridge where water was held. The following is a report of tests made to determine depths of penetration on pastures having contour ridges and in similar pasture areas where there were no ridges.

Moisture penetration tests in pastures (1–5 days after rains)

Location	Soil type	Slope	Rainfall	Moisture penetration contoured	Moisture penetration not contoured
		Percent	*Inches*	*Inches*	*Inches*
Natchitoches, La., 4.	Bowie F. S. L.	4	2	7	4
Do	Kirvin F. S. C.	3	2	13	10
Conway, Ark., 1	Hanceville G. S. L.	A	4	20	20
Do	do	B	4	20	17
Do	do	C	4	14	10
Do	do	D	4	13	6
San Angelo, Tex., 6.	Miles F. S. L.	0.3–5	16–25	60	37
Do	do	4.5	16–25	52	26
Do	Abilene S. C. L.	0.5–.3	16–25	52	35
Do	Miles F. S. L.	1.7–1.5	3	27	9
Do	Abilene S. C. L.	2	4.57	24	12
Do	do	3	4.57	19	8

The greatest general increase in growth of desirable vegetation has occurred on the more gentle slopes where the ridges have served as small levees to hold the rainfall on the ground and to spread it between the ridges to allow general absorption. In practically every case, however, regardless of the slope, there has been a pronounced increase of growth in the water channel just above the ridges, on the ridge bed, and immediately below the ridges. This is due, of course, to the water held by the ridge and to the effect of plowing. On the steeper slopes cattle frequently have been observed grazing on, or immediately adjacent to, the contour ridges where the grass was considerably better than on the area between.

Disadvantages of Contour Ridges

While the merits of contour ridges far exceed the disadvantages, there are some definite objections to be considered:

(*a*) Mowing for weed control is difficult. Where sheep are used in combination with cattle, this has not been a serious problem.

(*b*) Weeds make a rapid growth on the ridges.

(*Continued on p. 145*)

A CORDUROY COAT PROTECTS HIGH PLAINS FROM DROUGHT

By Fred C. Newport[1]

An example of pasture contour furrowing near Perryton, Tex., in the spring of 1936. Following three rains, moisture penetration tests showed 14 inches more on this pasture than on an adjoining, untreated pasture.

In the High Plains[2] an effective grass cover is needed to break the ground sweep of the wind and hold the soil in place. Recent years of agricultural expansion destroyed vast areas of native sod. The depression which followed, coupled with severe droughts, frequently resulted in indifferent farming or outright abandonment. The bare, unprotected soil was readily moved by the preying winds. Overgrazing joined with drought and was aided in the erosional process by the abandonment of neighboring fields. Depletion of land, often complete denudation, was the usual result.

But wind and drought and dust are to be more stubbornly opposed. Revegetation is to be encouraged by grazing management and mechanical treatment for maximum moisture utilization. A fundamental objective of the program is the restoration and maintenance of sufficient height and density of vegetative cover to prevent soil erosion.

Saving Each Drop as it Falls

The purpose of mechanical treatment of grasslands is to store and distribute moisture so that it will approximate as nearly as possible the results of natural and sufficient rainfall. The ideal is for each drop of rain to go into the ground where it falls. The mechanical treatment for moisture conservation has as its objective the maintaining of an even and thrifty distribution.

There are many problems involved in determining the most efficient method. Some of the prominent factors are climate, soil, topography, adjacent drainage area, type of vegetation, and the adaptability of farm machinery to the job. The contouring of range land is of three general types: The furrow with the ridge caused by the furrow slice minimized as much as possible; the ridge in combination with the furrow;

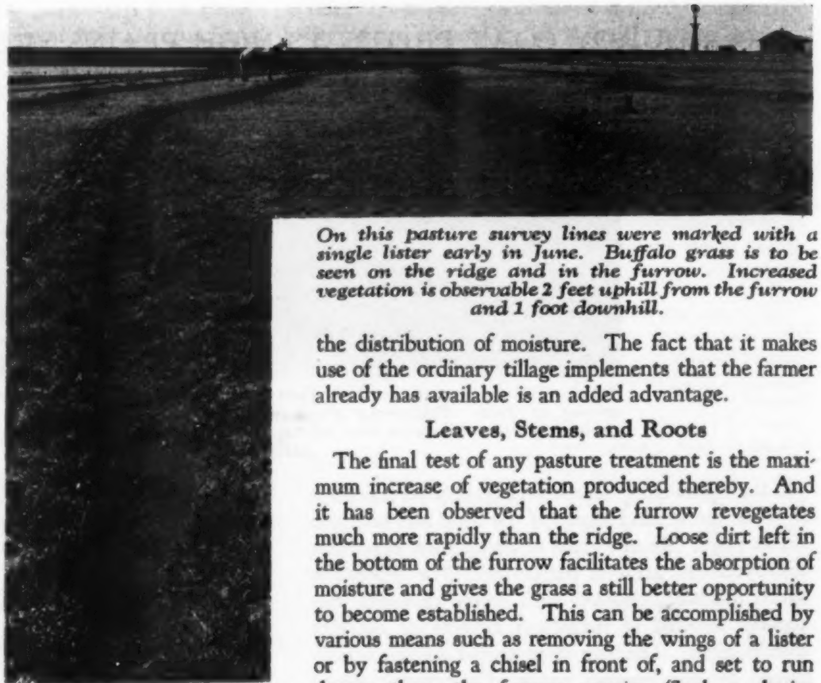
Increased vegetative growth as result of different types of furrowing on ranch near Amarillo, Tex. Note the advantage of plowing narrow, shallow furrows on the contour between ridges. Observe the increased vegetation on the upgrade side of the furrows. Technicians determined that areas so treated produced 106 pounds of blue grama and buffalo grass, as compared with 41.6 pounds on untreated areas.

[1] Regional agronomist, Amarillo, Tex.

[2] The November physical progress report showed that 81,542 acres had been contoured in Region 6, embracing parts of Texas, New Mexico, Oklahoma, Kansas, and Colorado.

and the terrace. The factors just enumerated will largely govern the method or combination of methods to be adopted.

While this work has not been in progress sufficiently long to point to any single method as being the most efficient, there have been enough observations made during the past year to indicate the practicability of each of the several methods under given circumstances. All factors considered, the method that at present appears to have the most universal application on the High Plains where the problem is largely the prevention of surface run-off, is the making of frequent, relatively shallow furrows on the contour, minimizing as much as possible the ridge caused by the furrow slice. This is done by spacing the furrows far enough apart to prevent overlapping. This treatment disturbs a minimum amount of sod and maintains to a maximum degree the distribution of moisture. The fact that it makes use of the ordinary tillage implements that the farmer already has available is an added advantage.



On this pasture survey lines were marked with a single lister early in June. Buffalo grass is to be seen on the ridge and in the furrow. Increased vegetation is observable 2 feet uphill from the furrow and 1 foot downhill.

Leaves, Stems, and Roots

The final test of any pasture treatment is the maximum increase of vegetation produced thereby. And it has been observed that the furrow revegetates much more rapidly than the ridge. Loose dirt left in the bottom of the furrow facilitates the absorption of moisture and gives the grass a still better opportunity to become established. This can be accomplished by various means such as removing the wings of a lister or by fastening a chisel in front of, and set to run deeper than, the furrow opener. (Such a device also minimizes dulling and breakage.) A hard, slick furrow bottom has a tendency to "bake" and crack, thus lessening its absorptive power and its opportunity for rapid revegetation.

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Pasture furrowing done with a two-row lister with mold-boards removed and point wings clipped. This arrangement disturbs a minimum amount of vegetation, and loose dirt thrown out along the edges is not sufficient to smother all grass plants. Several clippings of grass were made by the staff at Hereford, Tex., and the acre-yield of hay calculated: On the furrow, 720 pounds; on undisturbed pasture, 720 pounds; between 44-inch furrows, 1,373 pounds. Yield tests on two other pastures gave similar results.

PROGRESS REPORT ON CONTOUR FURROWING IN THE CORN BELT

A walking plow constructed these pasture contour furrows. Where topsoil is deep, furrows like these may be made without exposing subsoil, so difficult to revegetate. On many soils, however, the ridges do become infested with mullein, field sorrel, annual ragweed, and other weeds. On fertile soils, such weeds readily give way to good forage plants.

By Arnold S. Dahl [1]

Reports from Regions 3 and 5 show that 1,097 and 1,175 acres, respectively, have been contour-furrowed in pastures in these regions. This work covers a wide variety of types of furrows and methods of construction. The vertical interval of the furrows varied from 1½ to 4 feet, and the horizontal interval varied from 6 to 70 feet. A large number of the contour furrows have in reality been small level terraces or ridges, and small, shallow furrows placed close together have not been tried extensively in either of these regions.

Numerous types of equipment have been used. Walking plows from 12 to 16 inches in size have been used, also hillside plows, two-bottom plows, terracers and terracing plows. The width of the surface disturbed varied from 1½ to 9 feet when constructed with a plow and 4 to 18 feet when constructed with a blade terracer. Only rarely were single furrows plowed. The depth has varied from 4 to 10 inches.

Dams or checks were placed in many of the furrows at varying distances of 10 to 70 feet. These were constructed by shovels or by pulling the plow out at intervals. These checks were successful in preventing water from running along the furrows where they were not constructed exactly on the contour.

Usually, the furrows were successful in controlling erosion, as very little breaking-over occurred. In one instance 50 percent of a rainfall was lost from a pasture not contour furrowed, while an adjacent furrowed pasture lost no water. Another pasture was plowed around a gully and contour furrowed on only one side. The unfurrowed side was seriously damaged by gullying after a heavy rainfall, while the furrowed side showed no evidence of gullying. Many other projects reported that the furrows held all of the rainfall and controlled erosion successfully.

Penetration Measured

A few determinations of the depth of penetration of moisture in the furrows were made. These showed

[1] Agronomist, Soil Conservation Service, Washington, D. C.

that the moisture penetrated 3 to 4 inches in the furrow interval as compared with 18 to 24 inches in the furrow, and 16 and 18 inches just below the furrow. Data were reported by R. F. Copple at the annual meeting of the American Society of Agronomy, in Washington, November 17–20, on the penetration of moisture as a result of furrowing at Zanesville, Ohio. Soil-moisture determinations were made of samples of soil taken from 0–6, 6–12, 12–18, and 18–24 inch depths. These determinations showed that the soil was dry below the 12-inch depth in the furrow intervals. The moisture penetrated to the 24-inch level under the furrow ridge and below that level under the furrow bottom. The first 6 inches under the furrow ridge was as dry as the topsoil in the furrow intervals, but the moisture content increased with depth of soil until the 18-inch level was reached. This indicates that there was some lateral movement of water from the furrow. This additional moisture in the soil was sufficient to support a decided increase in the amount of forage in the furrow. This moisture would ordinarily have run off, and its conservation is a distinct gain for the vegetation in the pastures.

Mr. Copple reported on the work covering 242 acres on 22 farms in the demonstration project area. The furrows were made with a 14-inch walking plow and the whole pastures were usually limed, fertilized, and seeded with a pasture mixture. The furrow interval was usually 12 feet on a 15-percent slope and 25 feet on an 8-percent slope.

Forage Factor Increased

A study was made of the vegetative composition of the furrows, ridges, and intervals and on adjacent pastures which showed that in the furrows the forage factor was increased from 0.38 to 0.65. The forage factor decreased on the ridges where the vegetation had not fully recovered, which may have been due to the excessive lack of moisture experienced in the summer of 1936. The forage factor was only slightly greater on the contour-furrowed pastures as compared with the untreated pastures, according to the first year's data.

It was pointed out that this study of composition and forage value of the vegetation did not take into consideration the increased yield of forage on the contour-furrowed pastures. Since the pastures were being grazed, it was not possible to obtain actual figures of yields but observation showed that the vegetation was much more vigorous and green in the furrows and the stock preferred to graze this vegetation in preference to the drier vegetation outside of the furrows; the stock, therefore, grazed in the furrows more heavily and the grasses suffered from trampling. In spite of this heavy grazing and trampling the desirable grasses and clovers increased in the contour furrows.

Similar Results Elsewhere

Similar reports came from other projects. At one project, it was reported that the vegetation was 3 to 4 times as heavy on the contour-furrowed pastures as compared with an adjoining unfurrowed area. Only in a few instances did reports indicate that there was no increase in the amount of vegetation in the furrowed areas. Conditions for new seedings were very adverse during the past season due to the prolonged drought. For that reason, great difficulty was experienced in securing a stand on the ridges with the result that many of them grew up to the larger weeds.

Most of the furrows were made so deep that raw subsoil was exposed both in the furrow bottom and on top of the ridges. It is more difficult to obtain a stand of vegetation on such soil. Shallow furrows which do not expose subsoil will revegetate much more quickly and result in increased growth and productivity.

Farmers Appreciate Value

The reaction of farmers to contour furrowing was generally very favorable. Some projects reported that 90 percent of the farmers were in favor of furrowing their pastures. In some projects, the farmers were even more enthusiastic than the results received seemed to justify. They noticed the furrows holding water after rains and the increased vegetation along the furrows and observed the cattle grazing the green and vigorous forage. It was one of the easiest practices to sell to the farmers. Those who have contour-furrows in their pastures want more of them.

It is hoped that some demonstrations can be made of smaller furrows placed close together so that a wider range of conditions may be tested. On some soils it would appear that the ideal contour-furrowed pasture would be one where the ridges and furrows are adjacent to one another so that the surface of the ground represents a corrugated appearance similar to corn rows. It would appear that the furrows should be close enough together for the lateral spread of water in the soil to provide sufficient moisture for vigorous growth of vegetation over the whole pasture. This would vary with the permeability of the soil. The

(Continued on p. 145)

SPREADING WATER IN THE EAST

By Grover Brown [1]

Four types of furrows are being advocated in Region 1. They all serve the same main purpose—the obstruction and spreading of the downward flow of water over grassed areas, thus allowing longer time for absorption by the soil. All four types might be used on the same area and in conjunction with each other. Their construction is intended to be simple and yet efficient.

1. Uniform Slopes

This type of contour furrow is the one most commonly used on gently sloping pasture surfaces which are uniform in their topography. Such furrows are among those most easily constructed and require the least amount of engineering exactitude. They should be placed at 1- to 2-foot vertical intervals depending upon soil type, the condition of the turf, the steepness of slope, and the watershed above. When the furrow is 50 feet or less in length a skip of 3 to 10 feet is made to prevent draining of one furrow into another should the furrow not be a true contour and breaks occur.

These furrows may be constructed with the ordinary farm plow and usually, if made when the moisture content of the soil is most ideal for plowing, one furrow will suffice. It is better to distribute the water-holding capacity between a number of small furrows rather than between a few larger ones. Small furrows spaced at 6 to 15 feet, having the same capacity as large furrows at 25 to 50 feet, will be of more benefit to the grass. Short furrows mean less likelihood of damage resulting from slight variations from the contour. This makes the problem more simple for the average farmer.

2. Disposal of Water from Diversion Ditch

A terrace, a diversion ditch, or a diversion terrace is often used to conduct surplus water from cultivated fields. Often such outlets are in an adjoining pasture where the water may be used to great advantage in irrigating. By constructing a number of spreader-like furrows below the outlet, the water coming from the terrace may be distributed over a considerable area of pasture, thus adding moisture which, if trapped by furrows for sufficient time, may be gradually absorbed and applied to plant growth. Furrows such as these are placed on a slight terrace grade, with the longer ones near the top, so that water is carried gently from the beginning of the furrow at the outlet to the opposite end and there allowed to soak into the ground throughout the entire length of the furrow. The top furrow will not, of course, be able to absorb all of the water coming from the diversion ditch. Some of it will spill over to be caught by the succeeding furrows. By having the top furrows longer than those just below, what water is carried to the end of the furrow will run out and gradually spread until it reaches the next longer furrow down the slope where the same process is repeated.

The shorter furrows in this series ought to be more nearly on the true contour than the longer ones. This will tend to place a series of obstructions to the downward flow of the water and if enough of these individual obstructions are placed on the slope, their combined capacity will be sufficient so that little or no run-off water will reach the bottom.

3. Drainage of Spring Areas

In many of our pastures are areas characterized by springs or spouts which may flow intermittently for 8 to 10 months of the year, or continuously, depending upon the amount of rainfall and its distribution. Frequently a narrow strip of 3 or 4 feet in width extends from this spring to the bottom of the slope. This narrow strip receives an overabundance of moisture which often results in a swampy or exceedingly wet area covered with dense, rank vegetation.

By a series of small spreader furrows leading off at terrace grades from this strip, the surplus water may be distributed over an area of 15 to 40 feet in width. This will give additional moisture, often sorely needed, to grass on either side, and provide much more forage than otherwise could be produced.

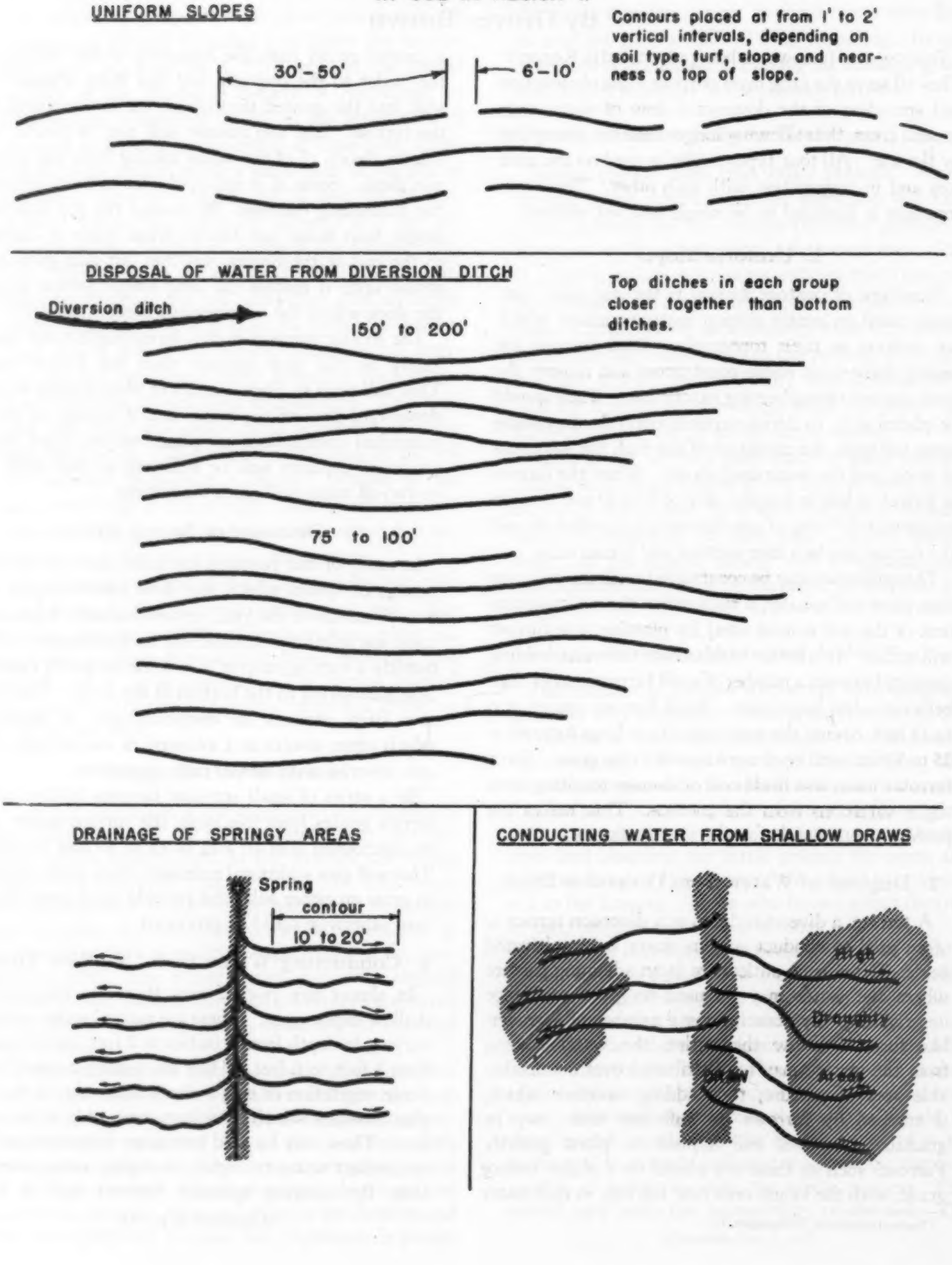
4. Conducting Water from Shallow Draws

In almost any pasture area there are natural low shallow depressions. These are natural water courses, varying in depth from 6 inches to 2 feet, and in width from 1 foot to 6 feet. They are usually covered with dense vegetation or sod, a direct indication of the surplus moisture which they have been able to accumulate. These may be used just as are irrigation ditches, to conduct water to higher, droughty areas on either side. By carrying spreader furrows out of these

(Continued on p. 145)

[1] Regional agronomist, Williamsport, Pa.

CONTOUR AND SPREADER FURROWS IN USE IN REGION I.



SPREADING WATER IN THE EAST

(*Continued from p. 143*)

ditches on a terrace grade, they serve to irrigate sections in great need of more moisture. It is neither advisable nor desirable to remove all of the water from this natural draw at any one place. Instead, the water should be diverted a little at a time down the slope, so that it may be utilized over a greater area.

The water naturally flowing down the shallow depressions very seldom does any real damage—this due to the depression's dense covering of sod. Normally it runs off and is wasted; but by this system of furrowing it is converted to the fields on either side of the draw.

By going up the slope and taking the furrow out on a grade varying from 1 to 3 percent for a short distance and then reducing to a more level grade, water may be brought to a point which is considerably higher than the draw directly across from it. Due to the fact that only a little water will be taken out by each spreader furrow, there is little danger of gullying in the furrow itself. Not all the water is taken out by the upper furrows, some of it being left for those at the bottom. By calculating the drainage area above the draw, and the amount of water which may be expected to run down it during hard showers, enough furrows can be constructed so that their combined capacity will utilize all of the surplus water flowing down any particular depression.

Furrowing in Corn Belt

(*Continued from p. 142*)

spacing of the furrows will depend on several factors. They should be so spaced that they will hold the run-off of an ordinary rainfall without being deep enough to expose raw subsoil when they are constructed. This would indicate that on deep soils the furrows may be deeper and spaced farther apart than on shallow soils. Shallow furrows also have an advantage in that the ridges and furrows do not interfere with the use of farm implements, and mowing can be accomplished without difficulty.

If the farmer needs his pasture for current use, it may be possible to construct the furrows farther apart than required for best conservation of soil and water, and additional furrows may be constructed in future years as the older ones become revegetated. However, on pastures with a thin cover and a highly erodible soil, where the construction of widely-spaced furrows may lead to overtopping and formation of gullies, it may be more desirable to construct a complete system of furrows at the top of the slope and leave the lower slopes to be furrowed when the upper slope has become revegetated.

Furrows Across United States

(*Continued from p. 138*)

(*c*) Where ridges are used on steep slopes (C or D), where the water cannot be spread, increased plant growth has been apparent only immediately adjacent to and on the ridges.

(*d*) In fields where practically all of the topsoil has been lost, and where there may be a network of gullies, ridge breaks are common.

Contour ridges may be constructed by the farmer with rapidity and at moderate cost, as compared with some other methods of protection. On an average slope, not severely gullied, a farmer with one team can mark and construct ridges on 2 acres per day. The expense to the Soil Conservation Service has been confined to that of running the lines.

Within the project and camp areas, 40,298 acres have been contour-ridged. Contour ridges have also been put in independently by a large number of farmers outside the areas. This indicates that the practice is effective, practical, and can be duplicated by farmers with their own labor and equipment and at their own expense.

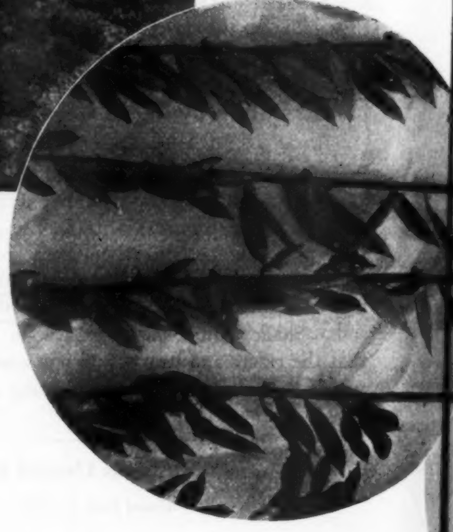
Protects High Plains

(*Continued from p. 140*)

Time is a factor of considerable importance from the standpoint of both vegetative response and operations. It has been observed that furrowing done in the spring about the time of heaviest rainfall gives a maximum response of grass with a minimum of weeds. Winter furrowing gives weed seeds a better chance to collect in the furrows, resulting in a greater growth of weeds. Grass will soon establish itself under this weed cover, however, in some instances deriving protection from extreme heat thereby. The work program of the farmer or rancher is another factor in determining the time of furrowing operations. Furrowing is beneficial, regardless of the time of year it is done. If the work program can be so arranged, spring furrowing nevertheless gives the grass its greatest opportunity to become quickly established.

Observational Plantings in th

Sheep bush, a shrubby perennial from the South African desert plateau regions, which has proved its value for control of sheet erosion in the Southwest.



By F. J. Crider

Head, Section of Conservation Nurseries

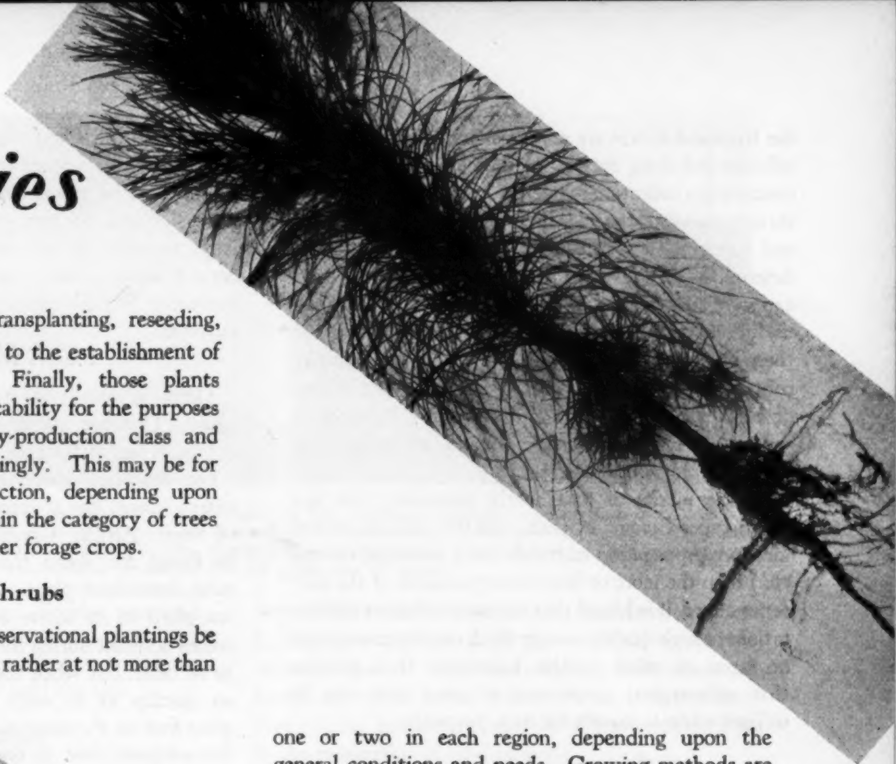
WHILE the major concern of the Nursery Section at this time is the production of nursery stock and the collection of seed in quantity for erosion control, a phase of its work of which the layman is not always aware is that of finding and bringing into use new plants which have outstanding value for the purpose in view—a constant flow of suitable plants to supply the needs of the project areas. This may be called the "observational" phase of the Soil Conservation Service nursery program. This work embodies the observation of a large number of species and variations of plants, and at the same time involves a most discriminating selection.

Plants must be chosen, in the first place, specifically for their known or potential conservational values. Plants which plainly possess no such values have no place in the observational plots. In line with the objective—a constant flow of suitable plants for erosion-control purposes—our seed and plant collectors are constantly on the lookout for native plants which in some outstanding particulars are worthy of being brought into the nurseries for further observation. Also, through special cooperative relations with the Division of Plant Exploration and Introduction of the Bureau of Plant Industry, and the efforts of our own Service, valuable introduced plants are being obtained for trial in the nurseries.

What is an Observational Planting?

A package of seed, from at home or abroad, acquired by design or chance; plantings in field or greenhouse for increase of seed; growth habits constantly observed, not only by the Nursery Section, but by all interested individuals and agencies of the Service, with a view to determining the plant's potential value and usefulness in connection with the various erosion control activities—this is the beginning of the "observational plant." Later, those species or strains which show promise are propagated in quantities sufficient for planting and trial under actual usable conditions. This affords opportunity for confirming nursery observations, more definitely determining relative plant values for particular purposes, and at the same time facilitates the development of successful methods

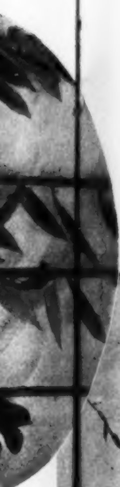
in the nurseries



of vegetative propagation, transplanting, reseeding, and other operations essential to the establishment of plants in desired locations. Finally, those plants which pass the tests of practicability for the purposes in mind go into the quantity-production class and are grown and handled accordingly. This may be for nursery stock or seed production, depending upon whether the plants come within the category of trees and shrubs, or grasses and other forage crops.

Trees and Shrubs

It is not the purpose that observational plantings be maintained at all nurseries, but rather at not more than one or two in each region, depending upon the general conditions and needs. Growing methods are determined largely by the character of the plants. In the case of perennials, such as trees and shrubs, they are planted in comparatively small groups according to botanical relationships, usually in portions of the nursery not readily usable for quantity production purposes. Notable examples of such plantings are the Elsberry, Mo., and Zanesville, Ohio, nurseries, where



Below and in circles:* Astragalus rubyi, *a legume recently discovered in the Ruby Valley, Mont., adapted to alkaline soils.

the trees and shrubs are set out mainly on rather steep hillsides and along draws. In the nursery at Elsberry, containing a collection of over 500 varieties of trees and shrubs, many of the plantings are arranged (the general topography of the nursery permitting) so as to determine the relative slope-stabilizing value and exposure-adaptability of the plants, as well as other useful characteristics. Indicative of the nature of these plantings, the collection at Elsberry, for example, contains among other groupings 5 outstanding strains of black locust, 6 species of juniper, 67 varieties of willow, 28 varieties of filberts, and 30 species and strains of plums and cherries.

As the merits of particularly promising tree and shrub types become evident, and the need is created for more propagation materials (seed, cuttings, offsets, etc.) than the more or less limited facilities of the nurseries afford, it is hoped that the establishment of plantations of high-quality woody stock may be encouraged on farms or other suitable locations. It is possible that submarginal lands may, in some instances, be utilized advantageously for such purposes.

Grasses and Legumes

The more extensive collections of observational plantings consist of grasses and other forage crops in nurseries located in the Great Plains and Western States, the largest being at Pullman, Wash., and including more than 2,000 different species and variations. Although containing many native species, these collections are greatly augmented by introduced materials which were obtained largely through the Division of Plant Exploration and Introduction of the Bureau of Plant Industry.

A number of these accessions already show highly desirable characteristics. This is true both with respect to grasses and legumes. Particularly interesting from the standpoint of erosion control, combined with forage value, are several forms of *Astragalus* and *Trigonella* of spreading, compact, stoloniferous habit as well as a number of the grasses.

Cooperative Exchange

In connection with the observational plantings, the interregional exchange of small lots of seeds and plants is important in that it provides a means for wider utilization of materials having value for specific purposes. Also, through cooperative understanding, small lots of seeds of various kinds are collected for use by the Division of Plant Exploration and Introduction of the Bureau of Plant Industry in promoting seed exchanges with foreign countries. This offers opportunity for the nurseries to secure desirable exotic plants for trial, the importance of which is seen in the large number of introductions being used in the Service erosion-control program, and the number of promising foreign species under observation in the nurseries.

Plants from Abroad

There is usually a story behind the introduced plant. This one about sheep bush (*Pentzia incana*) is typical and at the moment opportune:

For centuries, sheep bush (called "karoo" in its native haunt) has covered the desert plateau regions of South Africa. Gradually it became known that as forage for sheep this shrubby perennial was a most dependable plant. An extremely drought-resistant plant in its native environment, sheep bush becomes dormant during the dry season so that it appears to be dead; but when the rains begin, it comes to life so quickly as to seem miraculous. As the sheep graze first on the more succulent vegetation, the karoo has adequate time to regain green foliage—a natural balance of rotation grazing most advantageous in desert regions. Today sheep bush is one of the principal plants in the South African desert plateau areas for sheep forage in times of severe drought.

Cover for the American Desert

The original introduction of sheep bush into the United States was made more than 35 years ago by Dr. David G. Fairchild who for many years served as head of the Division of Foreign Plant Introduction, Bureau of Plant Industry. The original packet of seed was obtained from native African stands, and plantings were made at the plant-introduction gardens at Chico, Calif. Little attention was given these plantings except by a few individuals interested in exotic plants, until a small amount of seed was supplied us for experimental plantings to be made under southwest desert conditions.

At the time, soil conservationists were deeply interested in a cover for the desert—useful plants that would hold the soil and could survive under conditions of severe drought. Along with some 30 or 40 other species of widely varying growth habits, plantings of sheep bush were made under desert conditions in Arizona. After a year or two, all species had disappeared except the sheep bush. This, from the Service point of view, constituted a thoroughly con-

The three grasses at the left proved sufficiently satisfactory in the observational nursery at Tucson, Ariz., to justify more extensive trials for erosion control under natural conditions. They are **Eragrostis curvula, Eragrostis gp.,** *and* **Chloris berroi.** *The fourth,* **Enneapogon cencroides,** *was discarded because it was regarded as unsuited for the purposes in mind.*

vincing experimental result. The shrubby perennial from the South African desert-plateau regions had found a new home in the Arizona desert; it did not have to be aided by irrigation; it held the soil.

On Desert Range

In this observation under desert-range conditions, it was found that, in addition to possessing extreme drought-resistant qualities, sheep bush will reseed. This was in the way of a boon. The Service nurserymen are now propagating sheep bush for seed increase. Likewise, it is being planted in order to determine its further use for erosion control, especially in the Southwest. At present, the outstanding feature about this shrubby perennial is its value for general revegetation and control of sheet erosion—this because of its procumbent habit—combined with its high forage value, which is almost equal to that of alfalfa.

Thus karoo from the South African desert plateau came to the desert range of the Southwest.

And sheep bush is but one of many foreign plants now under observation at the various nurseries of the Service which already have demonstrated valuable characteristics for erosion control.

Plants from the Orient

Another interesting plant now being grown and propagated in the Soil Conservation nurseries is mahuang (*Ephedra sinica*), a low mat-forming perennial which possesses splendid sandbinding properties and extreme drought resistance combined with possible commercial value. Since this plant, introduced from China, produces the commercial ephedrin drug, it is hoped that it can be used more or less extensively on Indian reservations to hold the sand, and to provide monetary income for Indians having little source of livelihood. With its extraordinarily compact and deep root system, mahuang should be of inestimable value in the prevention of sand blowing.

A special strain of arborvitae, *Thuja orientalis*, is being propagated as rapidly as possible at the Elsberry, Mo., nursery. This hardy, upright, and fast-growing strain of arborvitae is especially suitable for windbreaks, being able to maintain itself under adverse conditions with no care whatsoever.

A trailing raspberry from Japan, *Rubus parvifolius*, with edible berries, is now under observation at the nurseries in several regions. This trailer has splendid soil-holding properties and is excellent for bird feed; but its most commendable property is that of its resistance to the usual raspberry and blackberry pests. It should therefore be of value in those localities where the climate is suitable for its growth and where a plant combining qualities indicated above is desired.

South African Grass

In the Southwest *Eragrostis curvula*, a perennial bunch grass which is a native of South Africa, is being grown in the nurseries for seed increase and project plantings. This grass is especially valuable because of its drought resistance, deep-root system, and its ease of propagation both vegetatively and by seed. Its heavy seed crops are easily harvested—an important feature—and it has been learned from observations that it will reseed under natural conditions. In the same

A view of the observational nursery at Pullman, Wash.

region, nurseries are trying out *Eragrostis sp.*, a mat-forming perennial grass (the best of some 30 grasses sent us by Miss M. Wilman of Kimberly, South Africa) which has special soil-binding advantages in that its offsets on prostrate culms take root readily. This grass is now being grown for seed increase and project plantings.

Ruby Valley Legume

The discovery of a heretofore overlooked native species is always highly satisfying to the plant collector. Of interest in this connection is a legume which was discovered recently in the Ruby Valley of south central Montana. This is *Astragalus rubyi* which in its native habitat is found growing in association with alkali grass and salt grass. *Astragalus rubyi* promises to become in the intermountain regions a forage legume of primary importance, and observational plantings made at different nursery centers suggest successful adaptation of this native species to a wide range of soil and climatic conditions. It is particularly adapated to soils of high alkali content.

Immune to Cedar Rust

Another native plant of special interest is the Ozark white cedar, a small spreading tree found growing in northwestern Arkansas and southwestern Missouri. This tree is particularly valuable because of its immunity to cedar rust, which restricts the use of common red cedar. In addition, Ozark white cedar has the further advantage of being able to grow under extremely adverse conditions. This small tree can be utilized for fence posts and its seed for bird feed. It is being grown and propagated at the Elsberry, Mo., nursery in the expectation that it will prove valuable for plantings in certain locations.

Native Tree and Layering Shrub

A striking example of variation in native woody plants, for which our plant collectors are watchful, is a strain of the wild olive (*Forestieria neomexicana*) found in Arizona, which differs from the more common form by its distinctly layering habit. This characteristic makes the plant especially valuable for the stabilization of gully slopes. Its value is further enhanced by ease of propagation and transplanting and the production of berries as food for birds. Stock plants are being grown in the nurseries for observation and as a source of propagation material.

Seed Production

Within the scope of "observational plantings" also comes the matter of determining the possibility of seed production under cultivation of certain grasses native to the United States, and this is becoming an increasingly important nursery function. Some of the more valuable range-erosion control grasses, as well as browse plants, have become almost completely eradicated by overgrazing and other improper land usage practices, so much so that it is impossible to collect seed of them in quantities sufficient for reseeding, the only recourse being to find out how to produce successfully the seed under cultivation. Again, in some sections there are years when, on account of prolonged

(Continued on p. 151)

COSTS COME DOWN ON 1,937 MILES OF TERRACES

By T. S. Buie [1]

Sharp downward trends in construction costs of terraces, treatment of terrace-outlet channels, and gully control during the 4 months' period from July to October, inclusive, are reflected in cost reports for the Southeastern Region.

In spite of an increase of 12.5 percent due to a change in wage rates for tractor operators in the region since July 1, terrace construction costs showed a decrease of approximately 16 percent for October as compared with July, very likely due to increased efficiency.

A decrease of 32.7 percent in the costs of treatment of terrace-outlet channels during the same period is attributed by our engineers to the more extensive use of meadow strips and other vegetated waterways for outlet channels, instead of the masonry and concrete structures formerly used.

Gully-control costs for the region show a decrease of approximately 34 percent. This is probably due largely to the comparatively recent practice of diverting the headwater from gullies, which virtually eliminates the necessity for permanent structures and greatly reduces the number of gully-control structures required.

In this connection it might be pointed out that where gullies are found in cultivated areas diversion of the headwater can usually be accomplished by terraces which drain the water away from the gully. Under other conditions this is accomplished by diversion ditches which can be constructed with machinery at much less than the cost of control structures in the gully itself.

By diverting the headwater, control of gullies can be effected much more readily with vegetation, since growth can be established with a minimum of mechanical structures once the volume of water flowing through the gully has been reduced to the amount of water falling directly into the gully and running down the sides.

Prior to July 1 the large amount of labor on relief rolls made it necessary to do more gully work than has been necessary since that time. Originally a large item in the cost of field operations, gully-control work is no longer a major activity.

The 16-percent decrease in terrace-construction costs was based on a total of 1,937 miles of terraces constructed in the Southeastern Region from July 1 to October 31. During the same period terrace-outlet channels constructed had a drainage area aggregating 17,241 acres, and gully-control work benefited 8,184 acres.

[1] Regional conservator, Spartanburg, S. C.

Observational Plantings

(*Continued from p. 150*)

droughts, the more abundant of the native grasses used in the erosion-control program are a failure. During such periods, particularly where irrigation facilities are available, cultivated plantings can be relied upon as a source of seed.

Favoring the practice of producing seed of native grasses under cultivation, as already demonstrated in some of the nurseries, good yields and purer seed may be expected from grasses so handled. Also, the information secured through such procedure, along with its demonstrational value, has the effect of encouraging farmers and stockmen to undertake the production of seed of these grasses as a cash crop. In a few instances in the Great Plains area this is already being done.

COMING.—A second article by Ben Osborn and H. L. Whitaker on *Mapping Natural Vegetation as a Background for Erosion Control and Wildlife Management;* a review of machinery developments, by Gerald E. Ryerson; discussions of cooperative relations, and cost-cutting.

Portion of an aerial photograph of a contoured field in Oklahoma.

PLANTING MATERIALS USED IN SOIL CONSERVATION

By L. D. Eagles[1]

A balanced soil conservation program involves the use of numerous seeds for strip crops, pastures, meadows, terrace outlets, cover crops, and green manuring. Before the practices could be introduced on many farms under agreement, it was necessary to apply commercial fertilizer and limestone. In some areas the slopes were so sharp and so badly eroded that it was inadvisable to plant cultivated crops, and for that reason kudzu crowns and trees came to play an important role.

During 5 months, July to November 1936, inclusive, the Soil Conservation Service purchased 2,807,173 pounds of seed for agronomic use. Of this quantity 2,142,061 pounds consisted of annual grasses, cereals, etc., used for cover crops, strip crops, pastures, meadows, and terrace outlets. Legume seed made up approximately one million pounds. The legumes are used for pastures, meadows, strip crops, terrace outlets, cover crops, green manure crops and forage crops. Perennial grasses which are used primarily for pastures, meadows, terrace outlets, and forage made up approximately three-quarters of a million pounds.

The following table shows the kinds, amounts, and principal uses of seed and other materials purchased through the Nursery Section during the 5 months covered:

[1] Associate agronomist, Nursery Section, Soil Conservation Service, Washington, D. C.

Item	Principal use	Amount
		Pounds
Oats (*Avena sativa*) and (*A. byzantina*)	Cover and strip crops, pasture	1,657,316
Rye (*Secale cereale*)	....do	449,980
Austrian winter peas (*Pisum sativum*)	Cover and strip crops, green manure	215,720
Hairy vetch (*Vicia villosa*)	....do	192,170
Western wheatgrass (*Agropyron smithii*)	Revegetating for permanent grazing	170,080
Alfalfa (*Medicago sativa*)	Strip crops, pasture and meadow	135,750
Biennial white sweet clover (*Melilotus alba*)	Pasture, strip, and cover crops	107,274
Smooth brome grass (*Bromus inermis*)	Pasture and hay mixtures, terrace outlets	103,305
Orchard grass (*Dactylis glomerata*)	Pasture, terrace outlets	73,450
Crested wheatgrass (*Agropyron cristatum*)	Revegetating dry lands for permanent grazing, terrace outlets	69,392
Slender wheatgrass (*Agropyron pauciflorum*)	Revegetating for permanent grazing	69,050
Italian or domestic ryegrass (*Lolium sp.*)	Pastures	59,680
Southern spotted bur clover (*Medicago arabica*)	Pasture-cover and green manure crops	53,700
Cowpeas (*Vigna sinensis*)	Cover and strip crops, green manure and forage	45,000
Redtop grass (*Agrostis alba*)	Pasture and meadow	41,675
Crimson clover (*Trifolium incarnatum*)	Strip crops, pasture, cover and green manure	34,350
Kentucky bluegrass (*Poa pratensis*)	Pasture, terrace outlets	32,729
Dallis grass (*Paspalum dilatatum*)	Pasture	31,505
Wheat (*Triticum vulgare*)	Cover and strip crops	31,400
White Dutch clover (*Trifolium repens*)	Pasture	29,765
Timothy (*Phleum pratense*)	Pasture and meadow	25,295
Hop or suckling clover (*Trifolium dubium*)	Pasture	21,835
Alsike clover (*Trifolium hybridum*)	Pasture and meadow	20,794
Red clover (*Trifolium pratense*)	Meadow, strip crops, pasture	18,055
California bur clover (*Medicago hispida*)	Pasture, cover and green manure crops	16,700
Biennial yellow sweet clover (*Melilotus officinalis*)	Pasture, strip and cover crops	16,200
Hubam clover (*Melilotus alba annua*)	....do	12,300
Bulbous blue-grass (*Poa bulbosa*)	Winter pasture and cover crops	9,775
Black medic (*Medicago lupulina*)	Pasture	7,960
Sour or annual yellow sweet clover (*Melilotus indica*)	Pasture, strip and cover crops	6,700
Canada bluegrass (*Poa compressa*)	Pasture	6,560
Chinese lespedeza (*Lespedeza sericea*)	Pasture, strip and meadow	6,200
Perennial ryegrass (*Lolium perenne*)	Pasture, meadow, terrace outlets	5,050
Carpet grass (*Axonopus compressus*)	Pasture, terrace outlets	3,950
Meadow fescue (*Festuca elatior*)	Meadow, pasture	3,798
Zawadke grass (*Puccinellia nuttalliana*)	Revegetating alkali soils	3,000
Reed Canary grass (*Phalaris arundinacea*)	Pasture, meadow	2,765
Indian wheatgrass (*Plantago sp.*)		2,750
Bermuda grass (*Cynodon dactylon*)	Pasture, terrace outlet	2,600
Rescue grass (*Bromus catharticus*)	Winter cover and pasture	2,000
California brome grass (*Bromus carinatus*) or (*B. marginatus*)	Pasture	2,000
Alfilaria (*Erodium cicutarium*)	Pasture and meadow	1,750
Sudan grass (*Sorghum vulgare sudanense*)	Strip crops, pasture and meadow	1,515
Tall oatgrass (*Arrhenatherum elatius*)	Meadow and pasture	1,500
Persian or Shaftal clover (*Trifolium resupinatum*)	Pasture	750
Tall or reed fescue (*Festuca elatior arundinacea*)	Pasture and meadow	550
Korean lespedeza (*Lespedeza stipulacea*)	Strips crops, pasture and forage	400
Sheep fescue (*Festuca ovina*)	Pasture and meadow	300
Fenugreek (*Trigonella* (*foenum-graecum*)	Cover and green manure crops	300
Rhodes grass (*Chloris gayana*)	Forage	300
Sainfoin (*Onobrychis viciaefolia*)	Green manure, forage and pasture	115
Rape (*Brassica napus*)	Pasture	100
Red fescue (*Festuca rubra*)	....do	15
Kudzu (*Pueraria thunbergiana*)	Cover crops, pasture, forage and gully control	[1] 2,264,000
Tree seeds	Nursery tree production	34,595
Trees	Woodland management reforestation	4,327,300
Sphagnum moss	Packing nursery stock	61,400
Commercial fertilizer	Terrace outlet and pasture improvement	[2] 4,040
Agricultural limestone	Soil improvement for legumes	[2] 1,012

[1] Crowns. [2] Tons.

WILDLIFE-SAVING FARM PONDS OF MISSOURI

By Cecil N. Davis [1]

Gully before dam was built.

During the summer of 1936, with stream beds dry and wells inadequate, the wildlife of Missouri congregated at thousands of ponds built by far-seeing farmers in recent years. Many of these had been provided as a part of the program of the Soil Conservation Service.

Gullies are favored as locations for ponds. The dams may back up water over a small overfall at the head of the gully, or a large structure farther down may help to fill branch gullies as well. This feature makes the building of ponds a successful and economical erosion-control practice.

As most farmers in this section are poorly supplied with water, the ponds aid the agronomist in his crop rotation program, especially that of rotation grazing. Many fields of prospective cooperators have neither

Pond just filled. No plantings made. Same gully as shown at left.

wells nor facilities for piping water from a distance, and springs in north Missouri are rare. Thus, the damming of a gully in a field designated as a temporary or permanent pasture often solves a knotty problem of

[1] Acting wildlife conservationist, Soil Conservation Service.

Vegetation holding 2-foot fill in inlet of pond, and providing food and cover for wildlife. Eight species 1 year old.

Submerged vegetation after 1 year's growth, providing protection and cupboard for small fish.

water supply, especially where beef-cattle and sheep are grazed or where young cattle are pastured for the season.

Forester's Viewpoint

As for the forester, his interest in the pond-development program on Missouri farms lies, chiefly, in the fact that it provides a larger and better-distributed water supply in the event of fires. At the same time, he is not indifferent to the fact that the raising of the water table may mean the survival of the black locusts, willows, or other trees which he may have planted in the vicinity.

From the standpoint of wildlife conservation a water supply is much more important than is generally realized. Food and shelter are the points usually emphasized as the controlling factors for upland game within their natural range, but only those who have observed them during the last two droughts know how birds, game, and fur-bearers concentrate near water supplies.

Counts of twoscore birds at one time in trees near an open spring are common. In August 1936 many muskrats were observed moving away from dry creeks to more moist locations.

Based on observations in the past three years, the following points are considered of outstanding importance for the most complete soil, water, and wildlife conservation program with ponds:

First, the pond should be at least one-half acre in size and at least 7 feet deep if it is to be used for watering livestock.

Second, any drainage from the farmstead should be diverted from the pond.

Third, the pond, dam, outlet, all raw land scalped to provide fill for the dam, and preferably an additional area equal to all the preceding, should be fenced stock-tight and protected against fire. Livestock should be watered by means of tanks fed by a gravity pipe line under the dam or by a windmill pumping from a pool by the side of the pond.

Fourth, proper environment for fish should be provided by introducing water plants of such types as will insure a renewal of the oxygen supply, food and protection for small fish, and support for fish-food animals. Certain of the plants will provide also dams for silt at the inlets of the pond, protection from wave action against the pond dam, and food as well as protection to birds, fur-bearers, and other wildlife fre-

(Continued on p. 159)

Burr-reeds on banks of pond one year from planting date, with new plantings in background. Three redwing blackbirds made nests in the reeds.

Protection against wave action proved by reeds and arrowhead one year after planting. Note the low water line.

THE LIFE HISTORY OF RAINSTORMS

Progress Report From the Oklahoma Climatic Research Center

By Katharine C. Hafstad [1]

A typical weather station in Blaine County, Okla., showing the installation of instruments.

The Oklahoma Climatic Research Center was established in October 1935 for the detailed study of local climatic variations which condition local differences in soil erosion. To this end nearly 200 weather stations spaced on an average of 3½ miles apart were established in Blaine, Kingfisher, and Logan Counties by the Division of Climatic and Physiographic Research in cooperation with the United States Weather Bureau and with the assistance of Works Progress Administration funds. Farmers selected from the relief rolls were trained as meteorological observers and a set of weather instruments was installed on each of their farms. Included are a rain gage, maximum and minimum thermometers, fan psychrometer, wind vane, and anemometer. Observations are made hourly from 7 a. m. to 7 p. m., and during storms the rainfall is recorded at 15-minute intervals. That which falls after 7 p. m. is collected and measured the following morning at 7 a. m. In addition, 100 supplementary self-recording rain gages have been installed on alternate farms on an average of 4½ miles apart. These supply continuous records of snow and rainfall for the entire duration of the storms.

120 Maps a Day

The observations are mailed to the Kingfisher headquarters where the data are transcribed onto maps under the direction of the project leader, Leonard B. Corwin. The actual work is performed by an office staff consisting chiefly of Works Progress Administration workers. For each day an average of 120 maps are prepared. These include daily maximum- and minimum-temperature maps and hourly maps of temperature, wind velocity and direction, relative humidity, and cloudiness. Rainfall maps are prepared for each 15-minute interval and for the accumulated rainfall by 15-minute intervals, by days, by months, and for the year beginning January 1, 1936. To insure accuracy the instruments are all tested weekly and if the observations are inaccurate, the finished maps will show inconsistencies which can easily be traced to their source. The few observers who failed to keep accurate records were readily identified and immediately discharged.

Reviewed in Washington

When the maps are complete they are sent to Washington for analysis and interpretation. In the January 1937 issue of the *Geographical Review*, Dr. C. W. Thornthwaite, head of the Division of Climatic and Physiographic Research, has presented the results of a preliminary analysis of these maps. The spotty character of the rainfall in the Great Plains has long been recognized but heretofore it has not been possible to obtain observations from a sufficiently large number of stations or at intervals short enough to permit a study of the rainfall distribution and its causes.

Recent studies of the Division of Climatic and Physiographic Research show that in the Great Plains the annual distribution of rainfall is neither cyclic nor synchronous and no pattern of rainfall distribution has as yet been determined. For example, the year 1919 was the driest for the entire period from 1905 through 1934 at Emporia, Kans., while it was the wettest at Phillipsburg.

Behavior Varies with Types

In the *Geographical Review*, Dr. Thornthwaite has presented a detailed analysis of five type storms which occurred over the project area in the spring of 1936. These show clearly that storms of different types have definite patterns of behavior, that the types "are sufficiently characteristic in size, shape, and distribution of intensity to be classified according to their morphology", and that through the study of a sufficient number it may be possible to develop a taxonomy of

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storms. If a storm of recognized type is reported by one of the established Weather Bureau cooperative stations, it may be possible from their data to forecast the behavior of the storm as well as the extent of the area which will be affected by it. Storm centers may or may not migrate. In the former case stations similarly located with reference to the center of the storm will report similar rainfall curves but the points of maximum intensity will occur at different times depending upon the rate at which the storm travels.

Polar Front Type

The rains of April 26 and 27 are of the Polar front type in which the front oscillates back and forth within narrow limits. On both days the precipitation occurred within the area of frontal oscillation.

On April 26 the station which first reported rainfall also reported the greatest total amount of precipitation (2.49 inches) for the entire storm and the maximum intensity (0.64 inch in 15 minutes) was experienced successively by three adjacent stations. Although the storm expanded and contracted areally, the center of greatest intensity never shifted more than 10 miles from the point where rainfall was first reported. With the exception of a few isolated stations, the precipitation was limited to the western third of the project area.

During the storm of April 27 scattered light showers occurred over the entire area in the morning. By afternoon, centers of high rainfall intensity (over 0.60 inch in 15 minutes) were reported by six stations in Logan County to the east but no rain fell in the western half of the area.

Storms of this type show why it is futile to correlate either crop production or erosion with average rainfall. The total rainfall over an area may be the same but one section may receive it at a critical period for plant growth. In another locality it may come when the soil is bare, and merely accelerate sheet or gully erosion.

Migratory Type

The storm of May 1 (illustrated by colored maps in the *Geographical Review*) is of the migratory type associated with the passage of a Polar front from northwest to southeast across the project area. By 4 p. m. the front had made its appearance in the northwest corner of the area, winds shifted from south to north, and the temperature dropped about 10° F. The same phenomena, with a fall in temperature of about 30° F., were observed progressively throughout the area and shortly after 7 p. m. the Polar front passed beyond the southeast corner. At 5 p. m. several irregular waves developed along the wind-shift line in Blaine County to the west, near the center of the area similar waves appeared at 6 p. m., and an hour later identical behavior was observed in Logan County to the east. This would indicate that the same waves had traveled eastward with the storm. As the amplitude of the waves increased centers of intense rainfall developed.

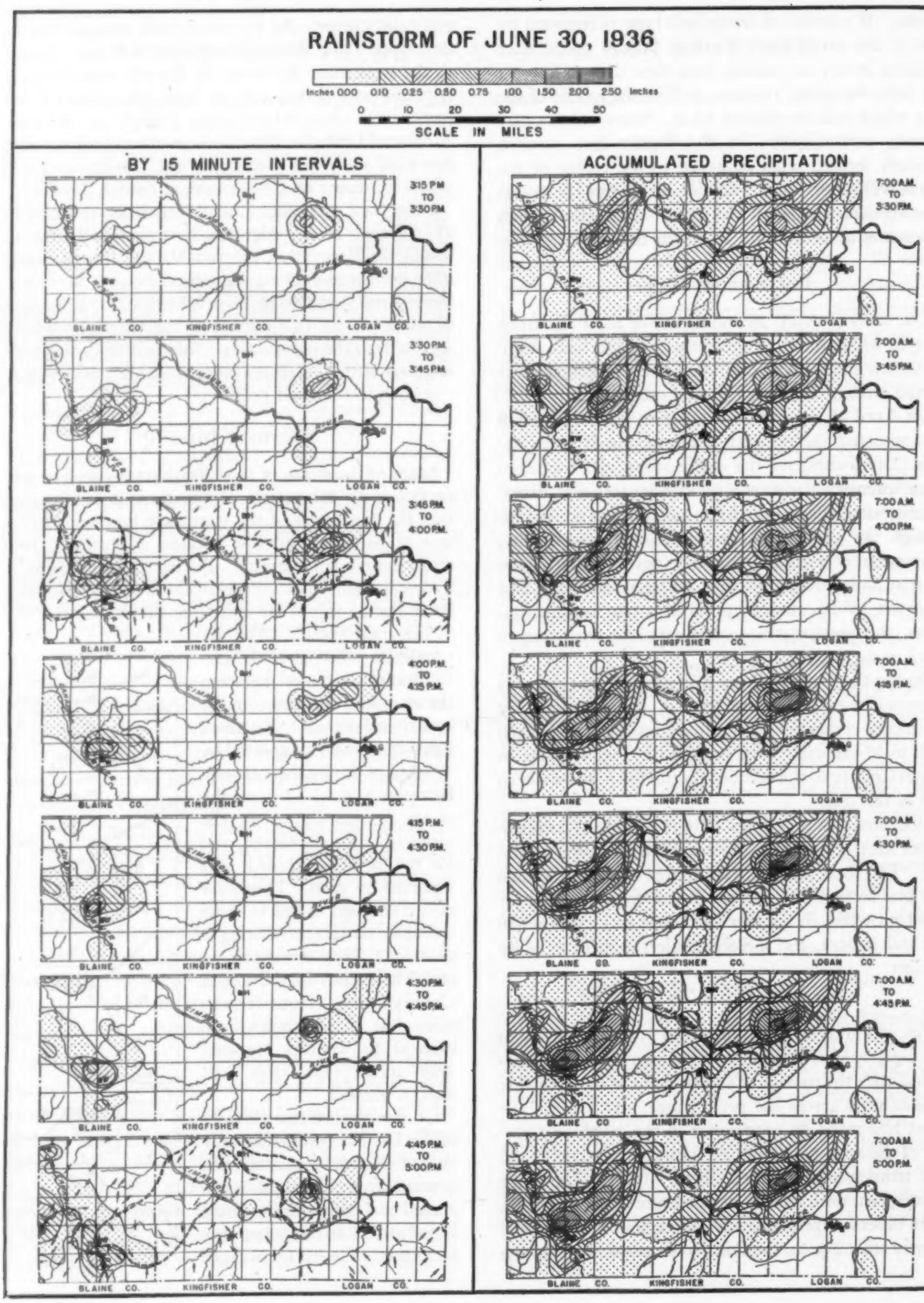
Centers of maximum rainfall intensities occurred in 13 different areas progressively from northwest to southeast, along the Cimarron Valley, the maximum intensity for any 15-minute period being 1.54 inches. During the storm more than 3,500,000,000 cubic feet of water fell on that portion of the Cimarron watershed within the project area. Information of this type suggests that rainfall-morphology studies offer a new approach to the flood problem.

Storm of June 30

Maps of the storm of June 30 are reproduced in connection with this article. From these it can be seen that the storm was of the stationary type and that it was of particular interest because it possessed two centers of rainfall intensity. During the early morning, Tropical Gulf (Tg) air overrode first the Modified Polar Pacific (Npp) air and later the Modified Polar Continental (Npc). The approximate positions of the discontinuity surfaces between the air masses are shown in the small panel of maps. Scattered light showers were reported by 30 stations during the morning. Between 3 and 3:15 p. m. the storm centers shown in the series of maps developed, and for the period 0.41 inch was reported by each. Thereafter rain continued to fall in these separated centers, amounting to a total of 2.27 inches in the Blaine and 3.81 inches in the Logan County center. However, stations less than 5 miles from each of the centers reported only traces (less than 0.01 inch) of rainfall.

Successive positions of the Polar front during the storm of June 30, 1936.

Of the five storms described by Dr. Thornthwaite, only that of May 8, associated with a warm front, brought widespread and fairly evenly distributed rainfall to the entire project area. The storms of April



RAINSTORM OF JUNE 30, 1936

26 and 27 were limited each to less than half of the areas, that of May 1 followed, in general, the Cimarron watershed, and that of June 30 had two widely spaced centers of maximum intensity, with rainless areas intervening. However, in each case the spottiness of the rainfall was associated with definite types of storms which are characteristic of the Great Plains. "In 2 or 3 years enough could be learned about the characteristics of storms in western Oklahoma to make it possible to approach the problems relating to soil and moisture conservation, land use, and flood control on an intelligent basis."

Varying Velocities Within Mass

Another phenomenon of great significance from the standpoint of soil conservation is shown by the wind charts reproduced in the *Geographical Review*. Parallel streams of air of different velocity develop in the main air mass. These streams or channels are parallel to the wind direction and are evidently not related to topographic features since they develop with winds from any direction. The wind may blow at the rate of 5 miles per hour at the edges of the channel and attain a velocity of 18 miles near the center. Further research is necessary to determine whether or not the channels tend to recur in definite positions or patterns, and it is suggested that such research may solve the problem as to why "some fields may suffer greatly from wind erosion and adjoining fields remain practically undamaged, even though soils and land use appear to be identical."

In conclusion Dr. Thornthwaite points out several important implications of rainstorm morphology analysis which indicate the need for the establishment of projects similar to the Oklahoma Climatic Research Center in entirely different climatic regions. Such analysis permits the determination of rainfall frequencies with far greater precision than formerly. Consequently when the expectancy of different types of storms for an area is established, the frequency of various precipitation intensities "may be determined by relating the area regularly experiencing this intensity to the total area of the storm". By determining the areal extent, intensity, and distribution, the total water content, and the usual migration habits of storms, the probable occurrence of rainfall over a given watershed during a storm of recognized type may be estimated. From information on the total amount of water deposited on a watershed, and its rate of fall, together with data on temperature, evaporation, and soil characteristics, the hydrologist will be able to compute with much greater accuracy the amount of run-off, infiltration, and the percentage of the total precipitation which may be added to the ground water.

The work of the climatic research center also illustrates the futility of trying to correlate soil erosion with monthly, weekly, or even daily precipitation. "The course of events must be traced step by step during individual storms." After type storms have been identified and their expectancy in a given area established, it will be possible to interpret data from existing weather stations more effectively from the standpoint of erosion and its control. Similarly, information concerning the magnitude and migration of type storms supplies data more suitable for the correlation of rainfall and crops than the average values which have heretofore been used.

Farm Ponds of Missouri

(Continued from p. 154)

quenting the water's edge. Seventeen species of leafy plants and shrubs have been planted in the Service-built ponds in Missouri, the most important of which are included in the following genera: *Saggitaria, Alisma, Polygonum, Echinochloa, Junens, Cyperus, Potomogeton, Ceratophyllum*, and *Spirodelia*.

Fifth, if possible the watershed should be planted to a permanent cover of sod or woodland. All raw areas on the dam and the edges of the borrow pit should be revegetated as soon as possible. Plantings of shrubs, such as buttonbush, red osier, dogwood, and wild plum, for protection and food for wild fowl and upland game, for erosion control, and for cooling the water should be made. Only a few trees need be used on the south and southwest sides, but not on the dam itself. Trees such as hackberry, hickory, black cherry, red cedar, red mulberry, and the native oaks are good; but cottonwood, elm, and willow may seed so profusely that they will overrun the area and, therefore, should not be encouraged. The shrub plantings should be in clumps, and should all be localized at one side or one end of the pond area, leaving the remainder an open grass plot for the freer utilization of the pond by waterfowl and for nesting sites for such species as quail and meadow lark.

Sixth, for the best use of the pond it is advisable to have supplementary wildlife cover and food in fields nearby. Often the gully below the pond can be fenced out and planted in erosion-control vegetation. Such a place makes an ideal lane for wildlife and may lead to waste areas, ungrazed meadows, overgrown fence rows, or a prepared wildlife area planted to shrubs and vines.

BOOK REVIEWS AND ABSTRACTS

By Phoebe O'Neall Faris

DEFICIENCIES IN BASIC HYDROLOGIC DATA. Special Advisory Committee, National Resources Committee. Washington, September 1936.

As set forth in this report of the special advisory committee on standards and specifications for hydrologic data, there is urgent need for additional knowledge concerning the behavior of water as it falls as rain or snow, is absorbed by the soil, runs off in streams or torrents, and is evaporated, for the well-ordered development of sound water conservation in the United States.

Herein is a discussion in some detail of factors involved in the gathering of accurate long-term hydrologic records as essential to efficient flood control, economical irrigation, effective water-reserve systems and land-drainage facilities. The cost factor in particular is stressed.

The past 6 years have seen severe drought conditions over large areas of the country. In these areas, losses to agriculture, stock and public water supplies have mounted into the hundreds of millions of dollars and have seriously impaired public welfare. Although no human power could have prevented the drought period itself, none the less by water conservation methods based upon precipitation, ground water, and evaporation records over a ong period of time, many of the serious losses could have been lavoided or at least reduced.

Other sections of the country suffered more or less disastrous floods. Expensive dams broke and waters flooded farms, cities, and villages; lives were lost and the costs soared. According to findings resultant from intensive studies made by the special advisory committee, these more or less major disasters might have been avoided had there been existent, as background for water-conservation methods, long-range records of the following natural conditions: Rainfall at high elevations; rainfall intensity; snowfall on mountain slopes in important drainage areas; maximum, mean, and minimum stream-flow; ground-water levels; evaporation, including that from snow and ice; impurities in water and their effects on health and on plant and animal life; soil conditions and vegetative cover; transpiration.

In the light of the above-mentioned requirements, the committee urgently recommends many additions and specific changes for the installations and expenditures essential to a permanent program for the gathering of long-term hydrologic data.

In regard to precipitation it is suggested that data of this kind should be made more effective "by the inspection and rehabilitation of existing precipitation stations; by the publication of hitherto unpublished precipitation records; by the establishment of 1,200 new cooperative rainfall stations in localities where rainfall is not now measured; by the establishment of 6 new first-order meteorological stations in high altitudes; and, especially, by the establishment, of 400 recording rain gages to collect data on intensity of rainfall, properly distributed as to area so as to average one to every 5,000 square miles." Summarizing costs for improving precipitation data, the committee estimates that the first year total would amount to \$396,000; while in succeeding years, with the program once installed, the total cost would drop to \$223,000.

The establishment of at least 500 snow-survey courses in mountain areas is recommended for the improvement of stream-flow forecasts above important irrigation, navigation, flood control, and power projects and privately irrigated lands. In connection with this it is stated that Federal interests are largely involved. In addition to the network of snow-survey courses, additional research at a few selected experimental courses should be initiated promptly to provide improvements in techniques employed in both old and new courses. As to cost for improving snow surveys, the committee recommends that distribution arrangement be such that Federal agencies supply some \$169,000, while non-Federal agencies produce for installation purposes an amount not to exceed \$13,000.

For the extension and improvement of stream-flow data the committee suggests the establishment of 500 base stream-gaging stations with 600 cooperative secondary stations, and in addition, the rehabilitation of 1,000 old stations. That a network of Federal stations is absolutely essential to a consistent and productive program of stream-flow measurement, is set forth by the committee as an urgent consideration.

According to the recommendations, ground-water data—information concerning the amount, position, and fluctuation—should be expanded by installation of 4,000 wells as base stations by the installation of 6,000 cooperative secondary wells; and by carrying on corollary geologic and hydrologic investigations, the latter to determine the most satisfactory location of wells and to apply data obtained to general water-resources problems in the various areas.

Thirty first-class stations and 250 second-class stations would be sufficient for the improvement of evaporation data. This would involve also the compilation of unpublished data, and at the same time research studies on the solar energy method of determining evaporation, and on evaporation from surfaces of snow and ice. Costs for evaporation data would be small, according to the advisory committee, with an initial amount of \$35,000, dropping to \$16,000 in the second and succeeding years.

For the collection of data adequate to an understanding of the quality of surface waters, it is recommended that 200 base stations be established for the measurement of mineral content, hydrogen-ion concentration, dissolved oxygen, suspended load and turbidity. Such stations should be located on sites of existing stream-gaging stations and should be maintained continuously for at least 10 years. At 100 of these base stations, regular measurements of water quality in respect to pollution should be made coincident with the chemical and silt measurements. At least 400 secondary stations are suggested, each of which should be operated for a 1-year period. Such secondary stations would be changed annually, with observations reported at intervals of from 5 to 10 years. The analyses would not be as detailed as those at the base stations, and their character would vary according to outstanding local problems of water quality, but their observations could be correlated with those taken at the base stations.

In closing that part of the report which deals with recommended standards and specifications for an expanded program for the collection of basic hydrologic data, the committee emphasizes the following: "It is only by establishing these expanded programs on a sound and scientific basis, taking full cognizance of the use of the data collected, making provision for continuing maintenance of a system of base stations, and using non-Federal cooperation at every practicable point, that a thoroughly useful body of basic hydrologic data may be obtained. With such a foundation of technical knowledge the Nation may look forward confidently to the effective and economical development and use of its water resources."

The appendix contains information, mostly in tabular form, concerning current programs for collection of hydrologic data, in the United States and European countries. Also included is the report submitted on November 6, 1935, by the special advisory committee on collection, compilation, and publication of basic data.

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